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The Relative Biological Effectiveness (RBE) of 15 MeV Betatron X-rays and 200 KV X-rays for lethality in Mice

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15 MeV ベータトロンX線と200 KV X線のマウス致死作用に及ぼす生物学的効果比

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東芝製15 MeV ベータトロン装置を用い，15 MeVX 線と200ＫＶX線の生物学的効果を全身照射によるマウスの半数致死線量につき比較した．仮にレントゲン単位及びベータトロンレントゲン単位で表わした半数致死線量の比をとると，生物学的効果比として0.66なる値が得られた．将来このエネルギーのX線の吸収線量への換算法が確立されゝばこの数値はそれに従つて換算し直されるべきである．

Introduction

The relative biological effectiveness of 15 MeV Betatron X-rays as compared with the 200 KV X-rays were studied. In spite of limited interest in radiation biology it is important to study the RBE in this energy region for clinical radiation therapy in determining irrdiation dose for cancer patient.[1] A median lethal dose is widely used and accepted as a quantitative measurement index for radiation effects. Hence, it was adopted in pursuing the present series of experiments.

Materials and Methods

Male mice of Na 2 strain weighing approximately 20 gm were randomly grouped for irradiation. Each dose group consisted of 10—20 animals. Each group was exposed to graded doses of 15 MeV Betatron X-rays and 200 KV X-rays respectively. It was followed as to survival and weight for 30 days. Ten animals or so were housed per cage. Laboratory chow and drinking water were supplied at livitum.

X-irradiation: The mice were placed in an Acrilite phantom, which is specially made for irradiation of mice. Only two mice were fixed in the center of the irradiation field, where the dose rate is approximately homogenous. An acrilite cover three cm in thickness was placed over the mice in order to ensure proper electron equilibrium. The mice were surrounded by rice as bolus during X-ray irradiation. The air supply to the mice was maintained adequately.

Exposure Conditions: The 15 MeV X-rays was produced by the Toshiba 15 MeV Betatron machine with a compensation copper filter at the Osaka City University Hospital .The target animal distance was 60 cm, and the dose rate at the position of the animals was approximately 11—20 "Roentgen" per minute.

The uniformity of the field over the region of interest was checked at the start of the experiment. The irradiation dose was mesured in the following manner. A Radocon chamber (probe model No. 601) was inserted through a hole on the side of the rice filled exposure box, so that it was entered between the two irradiated animals. The intergral dose was measured during exposure. The Toshiba KXC 200 machine was operated at 200 KV, TSD 90 cm, 20 mA, with 1.0 mm Cu 0.5 mm Al filtration (HVL Cu 1.72 mm). The dose rate at the position of the animals was approximatery 15 R per minute.

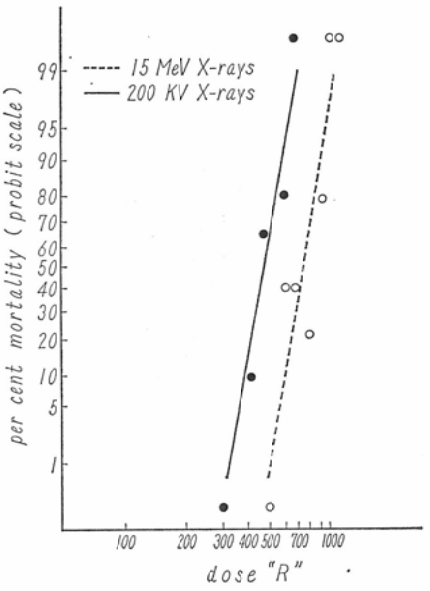
Results

The animals survival and weight were followed 30 days. An analysis of weight response following

Table 1. Mortality of mice exposed to 200 KV X-rays and 15 MeV Betatron X-rays

	dose "R"	number of mice	number of dead	per cent mortality
200 KV X-rays	700	20	20	100
	600	20	16	80
	500	20	13	65
	400	20	2	10
	300	20	0	0
15 MeV X-rays	1200	10	10	100
	1000	10	10	100
	900	10	8	80
	800	10	2	20
	700	10	4	40
	600	10	4	40
	500	10	0	0

Fig. 1 Survival Curves for mice exposed to 200 KV X-rays and 15 MeV Betatron X-rays



irradiation showed no qualitative difference between the two radiations. The lethality data for mice treated with 200 KV X-rays and 15 MeV X-rays are shown in Table 1 and plotted in Fig. 1. To facilitate interpretation of the results, probit transformation of the dose-lethality data was performed.

There have been some reports[2)3)4)5)] concerning conversion factors for high energy Betatron radiation. However, much more experimental work is needed before a relationship between exposure dose and absorbed dose at such a high energy radiation is established. Consequently in the presnt report as a tentative values of relative effectiveness a ratio of the measured dose in R and "Roentgen" was adopted. Since the LD50/30 of 15 MeV X-rays was 770 "R" and the LD50/30 of 200KV X-rays was 510R, a tentative RBE value of 15 MeV X-radiation being 510/770 or 0.66 for lethal effect.

Discussion

The RBE of 0.66 for 15 MeV Betatron X-rays as compared with 200 KV X-rays is consistent with other authors' observations of the relative biological effectivenss of high energy radiation for acute lethality in mice.

Lindop & Rotblat (1959)[6)] reported 0.72 for 15 MeV X-rays versus 250 KV X-rays and Sinclair & Blackwell (1959)[7)] reported 0.82 for 22 MeV X-rays versus 200 KV X-rays as determined by LD 50 in mice following whole body irrdiation, respectively. Moos & Fullee (1955)[8)] reported 0.75 for 22 MeV X-rays versus 400 KV X-rays and Sinclair & Blackwell (1962)[9)] reported 0.85 for 22 MeV X-rays versus 200 KV X-rays as determined by LD 50 in rats, respectively. Quastler & Clerk (1945)[10)] reported 0.78 for 20 MeV X-rays versus 180 KV X-rays, Tyree et al (1955)[11)] reported 0.8 for 22.5 MeV X-rays versus 180 KV X-rays, Friz-Niggli (1954)[12)] reported 0.75 for 31 MeV X-rays versus 180 KV X-rays, and Joyet et al (1959)[13)] reported 0.85 for 31 MeV X-rays versus 400 KV X-rays as determined by survival time of mice following whole body irradiation, respectively.

Summary

The relative biological effectiveness of 15 MeV X-rays from Betatron with reference to 200 KV X-rays (primary HVL Cu 1.72 mm) has been determined by using the slope of lethal effect of the mice as the biological endpoint. The RBE was estimated to be 0.66 for 15 MeV Betatron X-radiation for LD 50 of mice. When a definite method of dosimetry for high energy Betatron X-ray is established, the RBE value tentatively derived in the present study may be subjected to some changes.

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